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Antonio Visioli

(continued after Index)

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Advances in Industrial Control

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Series Editors' Foreword

The series *Advances in Industrial Control* aims to report and encourage technology transfer in control engineering. The rapid development of control technology has an impact on all areas of the control discipline. New theory, new controllers, actuators, sensors, new industrial processes, computer methods, new applications, new philosophies, . . . , new challenges. Much of this development work resides in industrial reports, feasibility study papers and the reports of advanced collaborative projects. The series offers an opportunity for researchers to present an extended exposition of such new work in all aspects of industrial control for wider and rapid dissemination.

Monographs from the academic control community commonly have a strong focus on control system *design*, but this is only one aspect of industrial control, so it is pleasing to be able to introduce a monograph into the *Advances in Industrial Control* series that is concerned with a topic from the equally important area of control *technology*. Kok Kiong Tan and Andi Sudjani Putra from the National University of Singapore have worked for several years with industrial engineers and university students on the technology of drives and their applications. Their work has covered teaching, research, and applications, and now their experience has been captured in this comprehensive monograph *Drives and Control for Industrial Automation*. One focus of the book is to describe the hardware and working principles of hydraulic and pneumatic servo-drives, electric drives, and piezoelectric drives, all of which are presented and reviewed in one chapter each (Chapters 2–4, respectively). A general control system structure for these drives is then given in Chapter 5, where, being an industrially-oriented monograph, the control focus and discussion is on proportional-integral-derivative (PID) control. The use of a generic control system structure across the differing drive technologies reinforces the authors' approach to the industrial servo-drive as a packaged unit integrating sensors, actuators (prime mover), power moderation, and control system. To incorporate such a drive unit into a process application leads naturally to a consideration of industrial process communication technology and communication protocols; these are described in Chapter 6, where the focus is on fieldbus technology. The final chapter of the book reports on recent and future trends in motion control. The key developments identified are an

industrial demand for miniaturisation and the growth of applications in the nano- and bio-technology fields.

Readers seeking an entry and introduction to the prevalent devices and current methods for servo-drive technology will find this monograph quite accessible. Such readers might include final-year undergraduate students, engineering postgraduates, industrial engineers, control engineers, and technologists, typically from the fields of electrical, mechanical, aviation, and process engineering. The breadth of the contents of the monograph means that it can also be used as a reference text for servo-drive technology.

Whilst this monograph from K.K. Tan and A.S. Putra has the advantage of comprehensiveness, readers seeking further specialist knowledge might find the following *Advances in Industrial Control* series monographs useful. In the field of hydraulics, the monograph *Hydraulic Servo-systems* (ISBN 978-1-85233-692-9) by M. Jelali and A. Kroll, for electric motors, the new monograph *Induction Motor Control Design* (ISBN 978-1-84996-283-4) by R. Marino, P. Tomei, and G.M. Verrelli. In the field of piezoelectric devices, the monograph *Piezoelectric Transducers for Vibration Control and Damping* (ISBN 978-1-84628-331-4) by S.O.R. Moheimani and A.J. Fleming, and finally in communications, the monograph *Measurement, Control and Communication using IEEE1588* (ISBN 978-1-84628-250-8) by J.C. Eidson. For PID control, the *Advances in Industrial Control* series offers a number of seminal texts including: *Advances in PID Control* (ISBN 978-1-85233-138-2) by K.K. Tan, Q.-G. Wang, and C.C. Hang with T.J. Hägglund; *Precision Motion Control* (ISBN 978-1-84800-020-9) by K.K. Tan, T.H. Lee, and S. Huang; *Practical PID Control* (ISBN 978-1-84628-585-1) by A. Visioli, and finally for something a little different, *Model Predictive Control System Design and Implementation with MATLAB®* (ISBN 978-1-84882-330-3) by L. Wang.

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Preface

Industrial automation has become an important feature today, especially in this age of rapid production and high precision. Automation allows industries to achieve the level of speed and quality unattainable by labour power; with affordable cost. While industrial automation is mostly profitable for mass manufacturing and homogeneous products, the bulk of industries produce goods in low quantity. In this situation, the challenge shifts into developing automation systems in industry that still justifies the installation cost. The knowledge and skill on this area has therefore become increasingly necessary.

This book recollects necessary materials related to servo control for industrial automation. It starts from a macroscopic view of servo control, especially for industrial automation, treating drives and control systems as inseparable entities. It then continues with detail discussions of major types of drives for precision control realization; namely servo hydraulic and pneumatic drives, electric drives, and piezoelectric drives. Each chapter contains detail discussions of the respective major components: actuators, sensors, and controllers—without going into the control theory. The techniques and theory of motion control itself is discussed in a separate chapter, considering that the control theory for all of the abovementioned drives is identical. For the same reason, digital communication protocol is also discussed in a separate chapter. This chapter is included as a recognition of the importance and growing trend of digitalization in motion and precision control. The more general trend in motion control is discussed in the closing chapter. Throughout the discussion, the integrity and nuance of mechatronics—a synergistic integration of the abovementioned components—are maintained, reflecting the reality of their synergy in today's industrial automation.

Despite its mechatronics nuance, the structure of this book allows traditional approach of step-by-step teaching to still be conducted should it be desired. Each chapter contains a material of its own that can be studied separately without compromising the understanding of the readers. This book is written for wide readership, from students, technicians, engineers, and researchers. The discussion is thorough, with concise basics yet sufficient details. Equations are provided as means to explain the certain concepts from the fundamentals such that it does not discourage inexperienced readers but is useful for those with prior knowledge. Readers who

wish to know the applications of various sensors, actuators, and control systems in industrial automation will find this book of value. Readers will also find that the flow of the book reflects the current approach and view taken by the industry, yet is still sensible and is easy-to-read, which they can relate to the prior knowledge they have learned traditionally.

The inclusion of hydraulic and piezoelectric drives, as well as control and communication, is intended to ensure that the book covers all necessary aspects in control system. The discussion in the book starts from the history and the basic principle of each device, as well as the assembled systems. The synergistic integration of actuators, sensors, control systems, and communication protocols are maintained throughout the course of the book to reflect the current trend in industrial applications. This book is intended for professionals, engineers, and postgraduate students whose areas of interest are drives, sensors, and control system design. For teaching purpose, it is most suitable to courses such as: Control System, Mechatronic System Design, Industrial Drives, and Instrumentation and Sensors. For professionals, it is most suitable for those working in system design and control, which require broad perspective of drives and control system of plants.

This book is equipped with many illustrations, especially to present the working principles and structures of the abovementioned industrial systems. The combined usage of words and figures are prevalent in the entire book to convey clear concepts to the readers.

This book would not have been possible without the generous assistance of many colleagues and friends. The authors would like to express their sincere appreciation to Dr. Huang Sunan, Dr. Zhao Shao, Dr. Tang Kok Zuea, and Mr. Chen Silu, who have provided invaluable materials for this book. The authors would also like to thank Mr. Oliver Jackson, Ms. Aislinn Bunning, and Ms. Charlotte Cross, who have been extremely helpful in the editing and publication of the book. Finally, we would like to dedicate the book to our families for their love and support.

Singapore

Tan Kok Kiong
Andi Sudjana Putra

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